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LEANNE MYNOTT
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AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant:

OPTISCAN PTY LTD

Invention Title:

OPTICAL ELEMENT

The invention is described in the following statement:

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OPTICAL ELEMENT

Field of the Invention

5 The present invention relates to an optical element for viewing laterally, of particular but by no means exclusive application in a confocal probe as well as in microscopy, endoscopy (including microendoscopy), colonoscopy, gastroscopy and like applications and especially confocal implementations of these.

10

Background of the Invention

15 Considerable advances in imaging the interior of the human body have prompted increased interest in the possibility of *in vivo* microscopic analysis. Confocal microscopy using light returned from fluorescence in tissue can be achieved in an endoscope with endoscope-head diameters around 5 mm with forward looking optics and a vibrating fibre scanner.

20 Further, probably the most labour intensive component in the existing flexible endoscopes are the as many as 11 element micro-lens assemblies. These lenses are so small that they are difficult to manufacture and handle, including being provided with antireflective coatings 25 after grinding and polishing. It is estimated that perhaps 200 separate operations are required to produce a completed lens assembly.

30 In addition, the second most expensive component in some prior art systems is the tuning-fork scanning mechanism.

35 There thus remains a need for still smaller and less expensive devices, in particular so that access can be gained to more remote and at present inaccessible regions of the body, including the internal surfaces of blood vessels.

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Summary of the Invention

In a first broad aspect, therefore, the present invention provides an optical element comprising:

5 a forward end for admitting light from a light source; and

a rear wall having an internal surface for reflecting said light laterally;

wherein said internal surface has an optical figure suitable for focussing said light.

10

Preferably said optical element includes a side wall, and said internal surface focusses said light to a point outside said side wall.

15

In one embodiment, the internal surface is a section of an ellipsoid, whereby the optical element is adapted to receive said light from a substantially point source.

20

In another embodiment, the internal surface is a section of a paraboloid, whereby the optical element is adapted to receive light in substantial parallel form.

25

Alternatively, said optical element includes at least one further optical element for changing said light from a divergent beam into a substantial parallel beam, and the internal surface is a section of a paraboloid.

The internal surface can, optically, have a reflective coating to increase the efficiency of reflection.

30

In a second broad aspect, the present invention provides a optical head for an endoscope or microscope, comprising:

an optical element with a forward end for admitting light from a light source, and a rear wall

35

having an internal surface for reflecting said light laterally, wherein said internal surface has an optical figure suitable for focussing said light; and

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a rotatable sleeve for supporting and rotating said optical element;

whereby said light can be scanned relative to said sample by rotating said sleeve and thereby the

5 direction in which said light is focussed by said internal surface.

In a third broad aspect, the present invention provides an optical element comprising:

10 a forward end for admitting light from a light source;

a rear wall having an internal surface for reflecting said light laterally; and

an external sleeve of non-uniform thickness;

15 wherein said internal surface has an optical figure suitable for focussing said light to a point outside said sleeve, said external sleeve is rotatable, translatable or both rotatable and translatable relative to said optical element whereby the distance of said point from said sleeve can be varied, and said external sleeve is transparent to said light in at least the region where said light is directed by said internal surface.

Brief Description of the Drawings

25 In order that the invention may be more clearly ascertained, embodiments will now be described, by way of example, with reference to the accompanying drawings, in which:

30 Figure 1 is a view of a scanning head for an endoscope according to an embodiment of the present invention;

Figure 2A is a schematic view of the optics of the scanning head of figure 1;

35 Figures 2B and 2C are schematic plots of the optics of the scanning head of figure 1;

Figure 3 is a view of a scanning head with variable depth for an endoscope according to a further

- 5 -

embodiment of the present invention;

Figure 4 is a partial view of another scanning head with variable depth for an endoscope according to a further embodiment of the present invention;

5 Figure 5 is a view of a scanning device for an endoscope according to a further embodiment of the present invention, in which the beam is collimated by means of an achromatic lens and the collimated beam is focussed by means of a paraboloid mirror;

10 Figure 6 is a view of a scanning device for an endoscope according to a still further embodiment of the present invention, in which the beam is collimated by means of a pair of on-axis mirrors and the collimated beam is focussed by means of a paraboloid mirror;

15 Figure 7 is a view of a scanning device for an endoscope according to a variation of the device of figure 6, in which the fibre is off-axis, the beam is collimated by means of a pair of off-axis mirrors and the collimated beam is focussed by means of a paraboloid mirror;

20 Figures 8A and 8B are schematic views of scanning by means of the principal mirror of the embodiment of figure 6;

25 Figures 9A and 9B are views of cylindrical elements for use with the embodiments of figure 5 to 7, for correcting astigmatism;

Figure 10 is a schematic illustration of how variable magnification can be effected by controlling fibre orientation with the embodiments of figures 1, 3 and 4 according to the present invention;

30 Figure 11 is a plot of θ_2 (the angle between the projected ray through second focus and the major axis) against θ_1 (the angle between a ray launched from first focus and the major axis) for figure 10.

35 Detailed Description

Referring to figure 1, according to a first embodiment there is provided a scanning head 10 for a confocal

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endoscope shown.

The head 10 has two flexible polymer tubes: a rotating inner tube 12 and a fixed cylindrical outer sleeve 14.

- 5 The inner tube 12 is chosen for torsional stiffness and low coefficient of friction for contact with the external sleeve 14. The optical fibre 18 of the endoscope fits loosely within the inner tube 12, and - including its coating - has a diameter of approximately 250 micron. The
- 10 inner diameter of the rotating inner tube 12 is about 1 mm; its external diameter is around 1.8 mm. The configuration of inner tube 12 with loose fibre is typical of patch cords used in optical communications systems.
- 15 The head 10 also includes an optical element in the form of a generally cylindrical plastic optical block 20, mounted on and co-rotating with inner tube 12. Optical block 20 is composed of either glass or a suitable polymer such as PMMA. Transparent polymers having a refractive
- 20 index close to 1.33 have been developed to match tissue refractive index in microscopy.

- 25 Light 22 (from the laser source of the endoscope) is admitted into the block 20 from the exit of the core of fibre 18, and fans out according to the numerical aperture of the fibre from the exit point into the block 20. The end wall 24 of block 20 has an internal surface 26 that reflects light 22 laterally. The internal surface 26 is a section of an ellipsoid, aligned so that the divergent
- 30 beam of light 22 is reflected laterally and focussed by the internal surface 26. Indeed, the light is focussed to a point 28 outside the sleeve 14, which is transparent at least in the region where it must transmit the light. Thus, point 28 represents a point observation field for
- 35 the endoscope.

Aspheric internal surface 26 is preferably coated to

- 7 -

maximize reflection, and can be produced very inexpensively by polymerizing plastic in moulds formed by single point diamond turning on a lathe.

5 □

It should be noted that the central ray from the fibre 18 reflects at right angles from the internal surface 26.

In assembly of the head 10, the fibre 18 is attached to 10 the optical block 20 and then the block is attached to the inner tube 12. During this latter operation, any excess fibre is taken up inside the loosely fitting tube 12. It should be noted that the relationship between tube 12 and block 18 need not have optical precision in the sense of 15 focal point accuracy. The main concern is positioning the exit tip of fibre 18 relative to the reflecting internal surface 26, which has a strict relationship to a single point on the block endface. It should also be noted that this fibre attachment point need not be on the optical 20 centreline of the block 20. This design point could be off-centre, anywhere within the inner diameter of the rotating tube 12, provided that the fibre 18 can still be attached in the design position.

25 Rotation of the inner tube 12 with the optical block 20 attached causes the scanning spot to move around the circumference of the outer sleeve 14 just beyond its outer surface. This rotation can be effected by any suitable means. During this rotation one can gather data 30 concerning the environment through which the focal spot moves, without necessarily producing an image. One application that is envisaged is the examination or at least characterization of plaque cells in blood vessels: as the observational point is rotated, a fluorescence 35 signature may be observed from the blood vessel as the outer sleeve 14 is drawn or pushed along the vessel. Statistics could then be obtained on the types of plaque

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as a function of length.

On the other hand, gradual longitudinal movement of the inner tube 12 alone during its rotation could gather

5 information for an image if the torsional rigidity of the inner tube is sufficient. The display could then be synchronised with the rotation of the inner tube at the proximal end. One simple method would be the use of a fine thread on the drive mechanism of the inner tube 12.

10 A simple side-viewing endoscope is thus provided with an external diameter of as little as 2 to 3 mm. The block 20 is a particularly simple one-piece element that forms an interface between fibre tip and focal point in the tissue

15 which occurs just outside the outer surface of endoscope tip.

20 Confocal operation is generally associated with an effective pin-hole for transmission and reception and the use of refractive optics as in a normal optical microscope. In the embodiment of figure 1, light is emitted from the small core of the optical fibre with the light returning from the focal point back through the fibre for analysis at the proximal end. The fibre end-
25 face acts as both launch and receive pin-hole.

Optical Considerations

30 The factors leading to the reflective design of this embodiment, as compared to prior art refractive configurations, are as follows. Considering the complexity of multi-element lens designs it may seem that the simple block design of the present embodiment may lack performance. However, as optical rays travel in straight lines within the block 20, the need for complex
35 compensation of wavelength dispersion throughout the optical system is obviated. Refraction can occur only at the exit of the cone of rays from the block. However, if

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the difference of refractive index between the materials in this region can be kept small there should be an advantage over other optical arrangements that leave an air gap between objective and sample and hence have a greater difference in refractive index.

5 As the present embodiment eliminates such as air space, special optic for launching from air into a curved higher index are not required.

10 There is merit in incorporating a lubricant between the optical block 20 and the outer sleeve 14, which would assist both optical and mechanical performance, by matching refractive index and reducing friction.

15 It will also be noted that the cone of rays emerging from the fibre endface does not diverge to the extent of a fibre in air, as occurs with vibrating fibre scanners. This reduces the area of the reflecting surface which is 20 required for a given numerical aperture, as compared to an air path to the reflector.

25 The use of aspheric optics suggests the use of polymer material for the block, which may reduce the cost to such an extent that the fibre and rotating tube system can reasonably be made disposable. By contrast a major concern with conventional in-line endoscopes using refractive optics is that, although the vibrating scanner 30 can be made very simple and inexpensive, the multi-element optics required between the fibre tip and the focal point remain complicated and relatively expensive; they must be complex to achieve the necessary dispersion and aberration performances. The small diameter of the rotating tube of the present embodiment makes the contrast even more 35 striking.

Although short focal length optics of appreciable

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numerical aperture are unpopular with fabricators, the present embodiment has no concave surfaces of optical quality. This reduces fabrication problems to some extent and makes possible manufacture by in-mould polymarisation, 5 by compression or by injection moulding.

Handling of such small optical components as the optical block 20 warrants special attention. The optically sensitive areas are the point 30 at which the fibre 18 is 10 attached to the block 20, the reflective zone on internal surface 26, and the light exit region of block 20 and sleeve 14. The rest of the cylindrical outer surface of sleeve 14 can therefore be safely handled and need not be optically smooth. This consideration is important for 15 polymer components where the soft material is susceptible to surface damage.

Optical Geometry

At the distal end of a flexible endoscope there is 20 generally a rigid section that houses the scanner mechanism and launch optics. The length of this rigid section can be a barrier to navigating sharp bends. For 25 vibrating fibre scanners the length of the scanning mechanism itself can be over 30 mm to which must be added the length of the refractive optics. A 5 mm diameter forward looking endoscope may well have a rigid length over 40 mm. For the rotating tube scanning head 10, there is the length of the optical block and any additional 30 length for a practical connection with the inner driving tube.

Firstly, the optics of the head 10 are illustrated schematically in figure 2A. It will be noted that the internal surface 26 is a portion of section of an 35 ellipsoid with a first focal point at the exit tip 32 of fibre 18 and a second focal point at the point observational field 28. This is also depicted as a

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schematic plot in figure 2B.

Figure 2C shows illustrates the trade-off between block length and numerical aperture. For a distance between foci (28, 32) of 4 mm, the rigid length is around 4 to 5 mm. As can be seen from the included angle in the exit bundle of rays, the numerical aperture has been increased considerably compared to that of the fibre 18. Leaving the offset at 1.1 mm and reducing the distance between foci to 2 mm, it can be seen that the block length can be reduced, but at the expense of the numerical aperture at the sample (or focus 28). The maximum numerical aperture is limited by the rays from the fibre diverging beyond the radial dimensions of the block 20 before reaching the reflecting internal surface 26. In practice, before this limit is reached the asymmetry in the exit rays may present a problem. It should be noted that, even in the illustrated example, some asymmetry is apparent in the rays of the exit bundle for the 4 mm case. Even so it can be concluded that the side viewing optics can be made shorter by an order of magnitude when compared with a scanner and refractive optics of the forward looking endoscope.

25 Confocal Operation

Optical sectioning involves manipulating the focal point to some controlled depth below the surface of the sample. For the side viewing scanner some means would be useful for adjusting the radial distance of the focus beyond the outer surface of the external fixed sleeve 14. Since the optical system between fibre tip and focal point is fixed in this embodiment, some other method is must be used to vary the optical distance between the exit surface of the block 20 and the outer surface of the external sleeve 14.

35

One such technique is shown in Figure 3, which does not require additional components. In this embodiment, the

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wall thickness of the external sleeve is non-uniform, varying from about 400 micron at the forward (or fibre) end of the head 40 down to 100 micron at the rear end.

Then moving the inner tube 12 and optical block 20

5 combination longitudinally relative to the outer sleeve 14 varies the penetration of the point observational field beyond the outer surface of sleeve 14 over a 300 micron range. Provided the sample is pressed against the sleeve 14, as would be expected in a blood vessel, the point observational field can be varied in depth in the sample.

The longitudinal movement of the inner tube 12 thus provides the depth scan and is not available for scanning in any other direction.

15 The taper needed for the depth scan could alternatively be introduced circumferentially by using an eccentric transparent rotatable polymer sleeve 50 located between the block 20 and the fixed outer sleeve 14, as shown
20 schematically in figure 4. As the rotatable sleeve 50 is rotated relative to the block 20, the depth beyond the rotatable sleeve 50 and therefore outer sleeve 14 to which the light is focussed is varied. An additional mechanism such as a third tube attached to the sleeve and rotating
25 with the tube would be used for driving the optical block 20. In this embodiment, it is envisaged that a refractive index matching fluid may be desirable between the block 20 and rotatable sleeve 50, and between the rotatable sleeve 50 and the outer sleeve 14.

30 In some variations of this embodiment, it may be sufficient to provide the outer sleeve 14 itself with a circumferentially non-uniform thickness, but such embodiments would typically require independent control of
35 the rotation of the block 20 and the sleeve 14 so that the view can be rotated and depth varied independently.

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In a still further embodiment, a scanning device for use as a confocal probe for the oesophagus (for example) is provided. In this embodiment, shown schematically in figure 5, employs focussing elements located optically 5 after the light emerges from the fibre tip so that the divergent beam is transformed into a parallel beam. A paraboloid rather than ellipsoid mirror is then employed to direct the light laterally and focus the parallel beam to a point observational field.

10 Thus, referring to figure 5, the scanning device 100 includes an inner tube 112 that accommodates the fibre 118 for transmitting light to the scanning device 100. As with head 10 of figure 1, the device 100 includes a 15 transparent outer tube 114, which is fixed and houses an off-axis paraboloid focussing mirror 120 (with axis of symmetry 122). In addition, the device 100 includes collimating elements in the form of an achromatic 20 collimating lens 130 for focussing the light diverging from the tip of fibre 118 into a parallel beam 132. The advantage of the parallel beam is that the location of the focussing mirror 120 can be varied along tube 114 without affecting the manner in which the light impinges on the focussing mirror 120. The benefits of this are discussed 25 below. In all cases, therefore, the parallel beam 132 is focussed by mirror 120 to a point 124 outside tube 114.

30 The paraboloid of revolution is the limiting case of the ellipsoid, and has the property that it takes a beam of parallel light rays (which are parallel to the axis of revolution) and brings them to a point focus 124. This focus, as has been seen, can be outside the tube 114 as with the embodiments the ellipsoid reflective surfaces.

35 Focussing mirror 120 is formed as a separate integer (with the mirror reflective surface operation either in air or with the rays reflected back into the optical polymer).

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Consequently, it can be rotated for scanning, as in the embodiments described above, effected with moving the fibre 118 or the collimating optics 130. Because the beam 132 is parallel, focussing mirror 120 can be translated 5 along tube 114 to provide longitudinal scanning so that a scanned image can be formed. Suitable means of effecting this translation are described below.

Figure 6 illustrates a variation 150 of the device 100, in 10 which - instead of an achromatic lens - a pair of on-axis mirrors 152,154 are used to collimate the beam emerging from the fibre 118. This device 150 is in other respects the same as the previous device 100.

15 Thus, a planar mirror 152 is located in front of the exit tip of the fibre 118 and perpendicular to the direction of the emerging beam. This mirror reflects the beam back towards the fibre 118. A second mirror 154, of parabolic shape, is located about the fibre 118 (having an aperture 20 to accommodate the fibre 118). This parabolic mirror 154 collimates the beam and reflects back along the device 150.

Figure 7 illustrates an off-axis variation 160 of this use 25 of collimating mirrors, in which the fibre 118 is off-axis and a pair of off-axis mirrors 162,164 are used to collimate the beam emerging from the fibre 118. This device 160 is in other respects the same as the previous device 150. It will be noted that the mirrors are off-axis with respect to the tube 114, but that the parabolic mirror 164 has an axis of symmetry aligned with the fibre 118.

Figures 8A and 8B illustrate scanning by means of the 35 paraboloid mirror 120 of the embodiment of figure 6. Scanning is effected in like manner in the embodiments of figures 5 and 7, or other electromagnetic, pneumatic,

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hydraulic or other actuation mechanisms can be employed.

The initial position of the paraboloid mirror 120 is shown in figure 6. Figure 8A illustrates the motions of the 5 mirror for axial or longitudinal scanning, which can be effected by any suitable means, such as a stepper motor or a pneumatic drive located behind the mirror 120. As the mirror 120 is advanced or retracted within and relative to tube 114, the point observational field 124 moves in 10 parallel with the mirror 120 so that a longitudinal scan is performed.

Other methods for effecting longitudinal scanning are possible. For example, a micro-grooved thread may be 15 turned on a section of metal on the outside of the rotating mirror 120. This thread can be produced with a fine diamond point and it can work as a screw thread with a pitch of less than a micron. The matching thread can be formed by pressing the metal surface against clamping 20 sections of soft plastic, such as Teflon tape.

The rotation of the mirror would thus also serve to advance the assembly by one micron (or whatever pitch is used) per revolution thus generating a raster.

25 It would also be possible to produce a fast axial or longitudinal scanning motion of the focussed spot by reciprocating vibration mirror 120. Such an oscillatory motion could be produced electro-magnetically. A 30 refinement of this design employs a counterweight that vibrates 180° out of phase to cancel unbalanced forces.

Resonant oscillatory rotational scanning movement of the mirror could also be achieved by a similar arrangement.

35 Figure 8B illustrates the motions of the mirror for depth scanning, that is, for focussing at greater or lesser

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depth within the sample (such as tissue). As the mirror 120 is moved laterally within and relative to tube 114, the point observational field 124 moves towards or away from the tube 114, thus scanning to less or greater
5 depths.

This motion can also be effected by any suitable means, such as an electromagnetic or pneumatic drive (such as an
10 inflatable sac) located between the mirror 120 and the tube 114.

In all of the above embodiments, in order to provide 360° circumferential scanning a miniature electric motor and gearbox (not shown) can be employed to rotate the mirror.
15 In the paraboloid mirror embodiments, the motor may be mounted on a piston that can be advanced in an axial or longitudinal direction by the movement of fluid down a pipe into the piston. This arrangement provides, therefore, simultaneous scanning in two orthogonal
20 directions (viz. longitudinal and rotational).

In some of the above embodiments, astigmatism is produced by the difference in radius of cylindrical curvature between the inner and outer surfaces through which light
25 passes. In figure 1, these surfaces are the outer surface of the block 20, and the sleeve 14. These will not a great difference in radius of curvature, but it will be appreciated that, in the embodiments shown in figures 5 to 7, this difference will be considerably greater.

30 Further, fluid or tissue in contact with either or both of the surfaces will change the degree of astigmatism in the system.

35 The optical systems disclosed in figures 1 and 3 will have essentially no astigmatism if the plastic of block 20, the sleeve 14 and any lubrication liquid between them have

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refractive indices close to the refractive index of the sample. For human tissue this is approximately that of water, or $n \approx 1.33$. Indeed these systems should have essentially no optical aberrations when imaging point to point. There are available optically clear polymer materials with refractive indices close to that of tissue and water.

In the event that it is difficult to mass-produce these shapes with such low refractive index materials there are a number of possible alternative ways to achieve that same result.

Firstly, in the embodiments of figures 5 to 7, the mirror 120 may be rotated in a fluid within the transparent tube 114. The refractive index of the liquid should be 1.33, approximating the refractive index of the tissue to be examined. If the material of which the tube 114 is made is of a substantially higher refractive index than the liquid should also be of a refractive index higher than 1.33 by an amount dependent on the refractive index of the wall material of tube 114 and its thickness.

In the embodiments of figures 1, 3 and 4, it would also be possible to include a moulded cylindrical surface, at the surface where the light exist the optical block 20 in the direction of the specimen or sample.

Secondly, astigmatism can be compensated for by providing additional aspherical elements in the optical path. Astigmatism in the embodiments of figures 5 to 7 can be compensated for by means of cylindrical optical elements that rotate with the focussing mirror 120, and placed just inside the viewing section (i.e. through which the sample is viewed) of the outer tube 114.

Examples of suitable cylindrical elements are shown in

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figures 9A and 9B, in which cylindrical elements 172,174 are adapted to be located inside tube 114. Referring to figure 9A, correcting element 172 has a planar incident surface 176 and a cylindrical exit surface 178. The 5 cylindrical element 174 of figure 9B has a cylindrically concave incident surface 180 and a cylindrical exit surface 182.

10 Cylindrical lenses can, alternatively, be introduced at an earlier point in the optical path. It would also be possible to figure the mould that produces the surface of the focussing mirror 120 so as to include an optically cylindrical component.

15 It may also be possible, in some embodiments, to provide variable magnification by controlling fibre orientation. Figure 10 shows elliptical mirror with eccentricity 0.84 focussing the field from a fibre tip at the focus F_1 onto focus F_2 . With the fibre oriented so that it casts 20 lightcone $F_1 P_1 P_2$ onto the mirror, lightcone $p_1 p_2 F_2$, which is the mirror image of lightcone $F_1 P_1 P_2$ reflected in the ellipse's minor axis, is brought to a focus at F_2 such that the numerical aperture of the cone converging on the 25 object is precisely equal to that of the cone launched from the fibre. The magnification of this imaging system is then precisely unity and small movements in the fibre tip are translated into motions of the same magnitude and opposite sense in the tip's image.

30 By contrast, if the fibre is now tilted, so that its tip stays at the focus F_1 but casts lightcone $F_1 q_1 q_2$ onto the mirror, the lightcone $q_1 q_2 F_2$ is now of much higher numerical aperture than that of the cone launched from the fibre. Small tip movements are now translated into 35 magnified movements of the tip's image.

The angle θ_1 between a ray launched from F_1 and the major

- 19 -

axis is related to the angle θ_2 between the projected ray through focus F_2 and the major axis by:

$$\sin(\theta_2) = \frac{(1 - \varepsilon^2) \sin(\theta_1)}{1 + \varepsilon^2 - 2\varepsilon \cos(\theta_1)},$$

5

where ε is elliptical eccentricity. The relationship between θ_1 and θ_2 , is plotted in figure 11, with θ_1 in radians plotted along the horizontal axis and θ_2 in radians along the vertical axis, for an eccentricity of 0.84. The 10 maximum magnification of the device is given by the gradient of this curve at $\theta_1=0$ and is:

$$M_{\max} = -\frac{1 + \varepsilon}{1 - \varepsilon}.$$

15 More generally, the magnification for a small numerical aperture lightcone is given by:

$$M = -\frac{(1 - \varepsilon^2) \cos(\theta) + 2\varepsilon}{(1 + \varepsilon^2 - 2\varepsilon \cos(\theta))^2} (1 - \varepsilon^2),$$

20 where θ is the angle between the chief ray of the lightcone launched from the fibre and the major axis.

25 This technique is likely to have limited utility, as it will give rise to considerable spherical aberration and reduced light efficiency.

30 Modifications within the scope of the invention may be readily effected by those skilled in the art. It is to be understood, therefore, that this invention is not limited to the particular embodiments described by way of example hereinabove.

- 20 -

In the preceding description of the invention, except where the context requires otherwise owing to express language or necessary implication, the word "comprise" or 5 variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

10

Further, any reference herein to prior art is not intended to imply that such prior art forms or formed a part of the common general knowledge.

15 Dated this 27th day of February 2004

Optiscan Pty Ltd

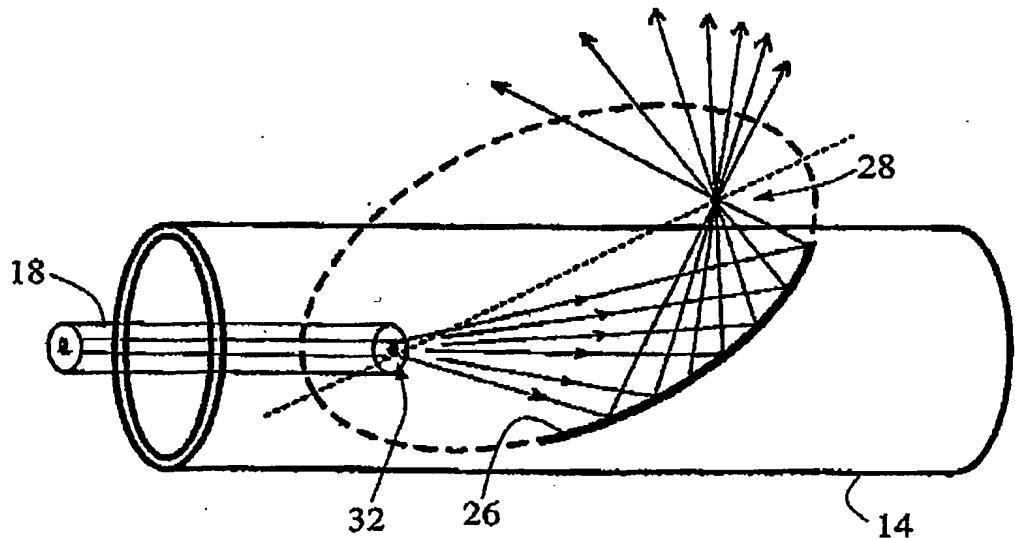
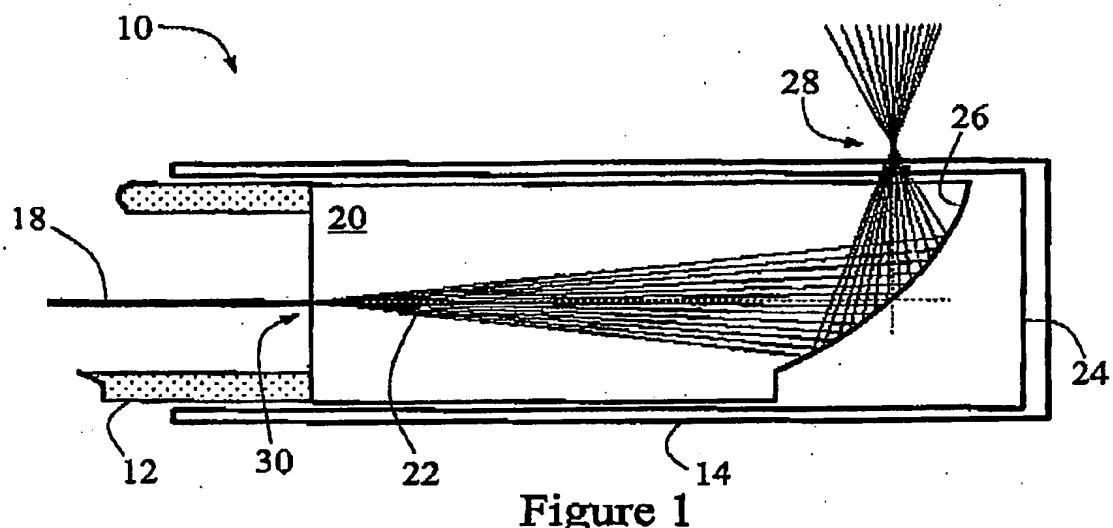
By their Patent Attorneys

GRIFFITH HACK

Fellows Institute of Patent and

20 Trade Mark Attorneys of Australia

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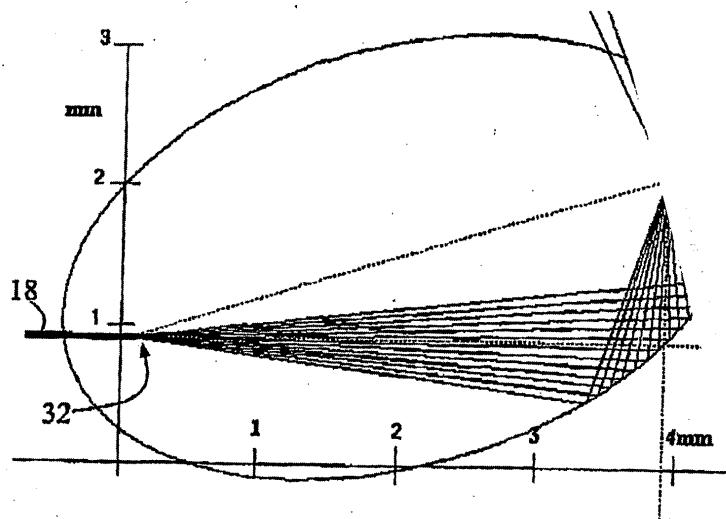


Figure 2B

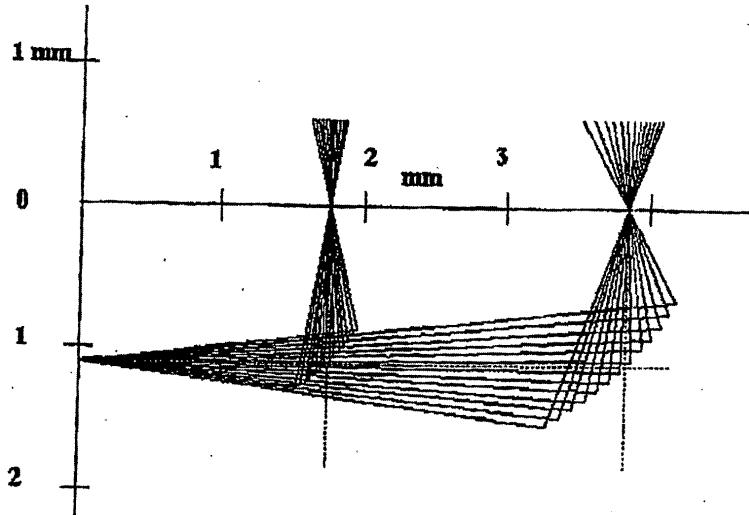
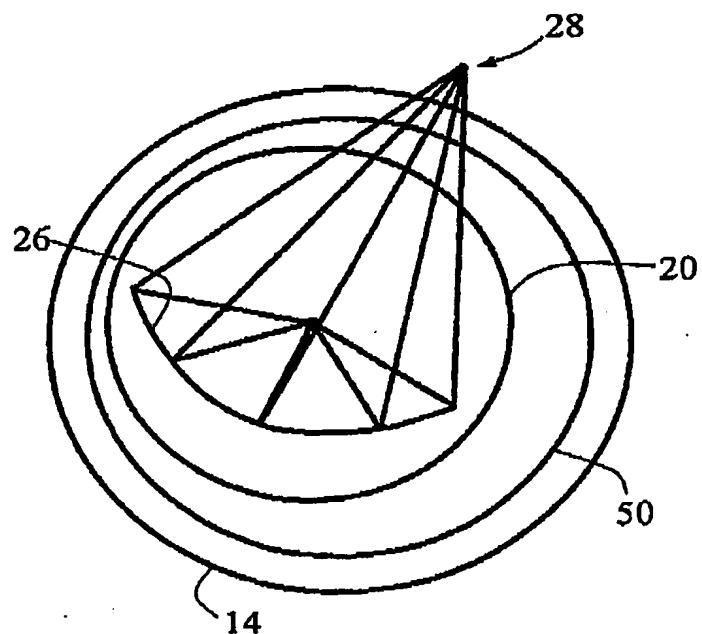
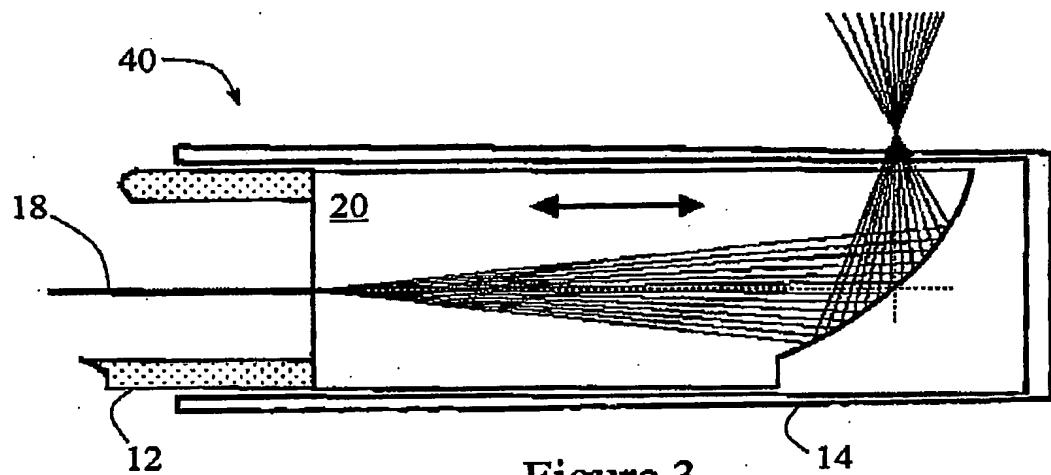


Figure 2C

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4/8

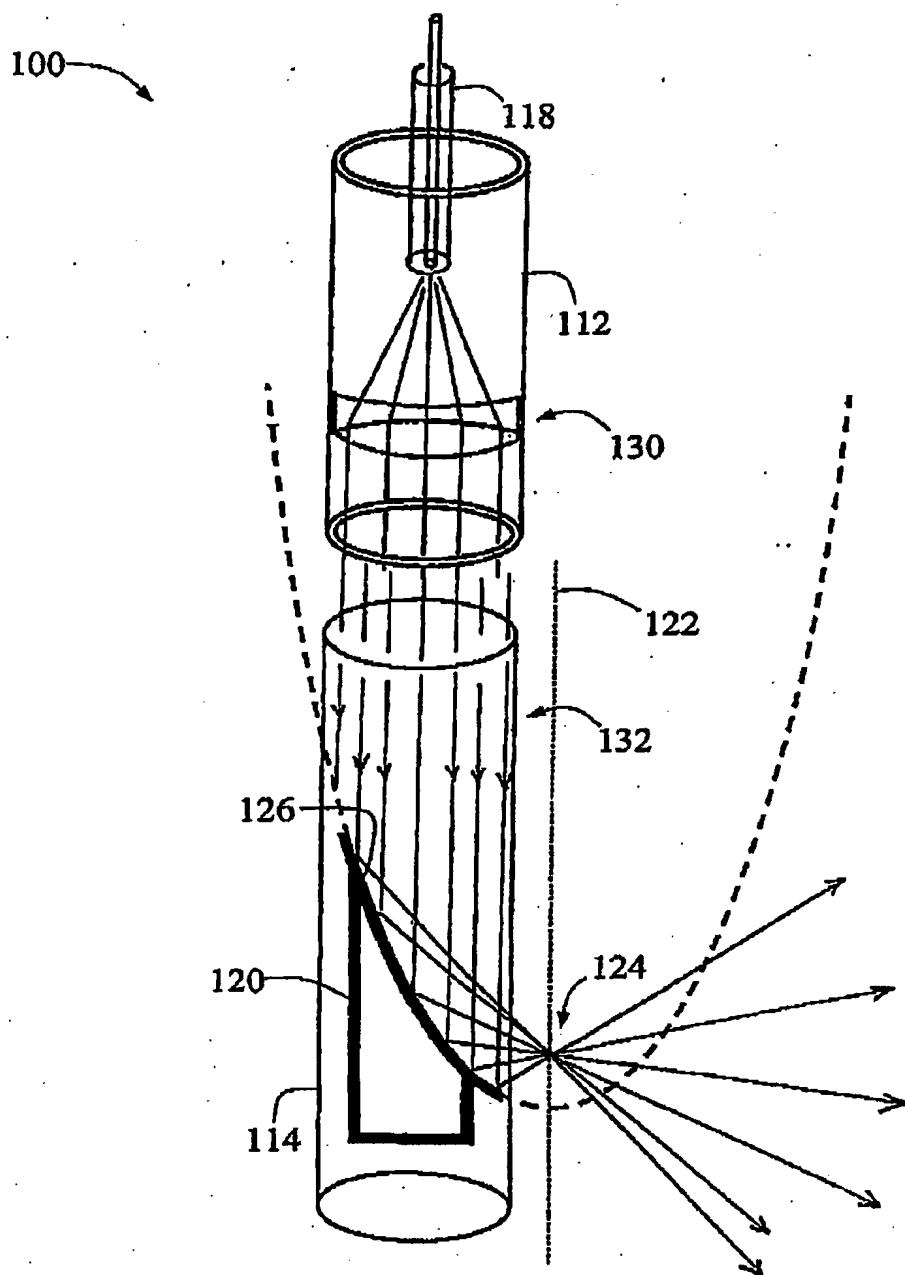


Figure 5

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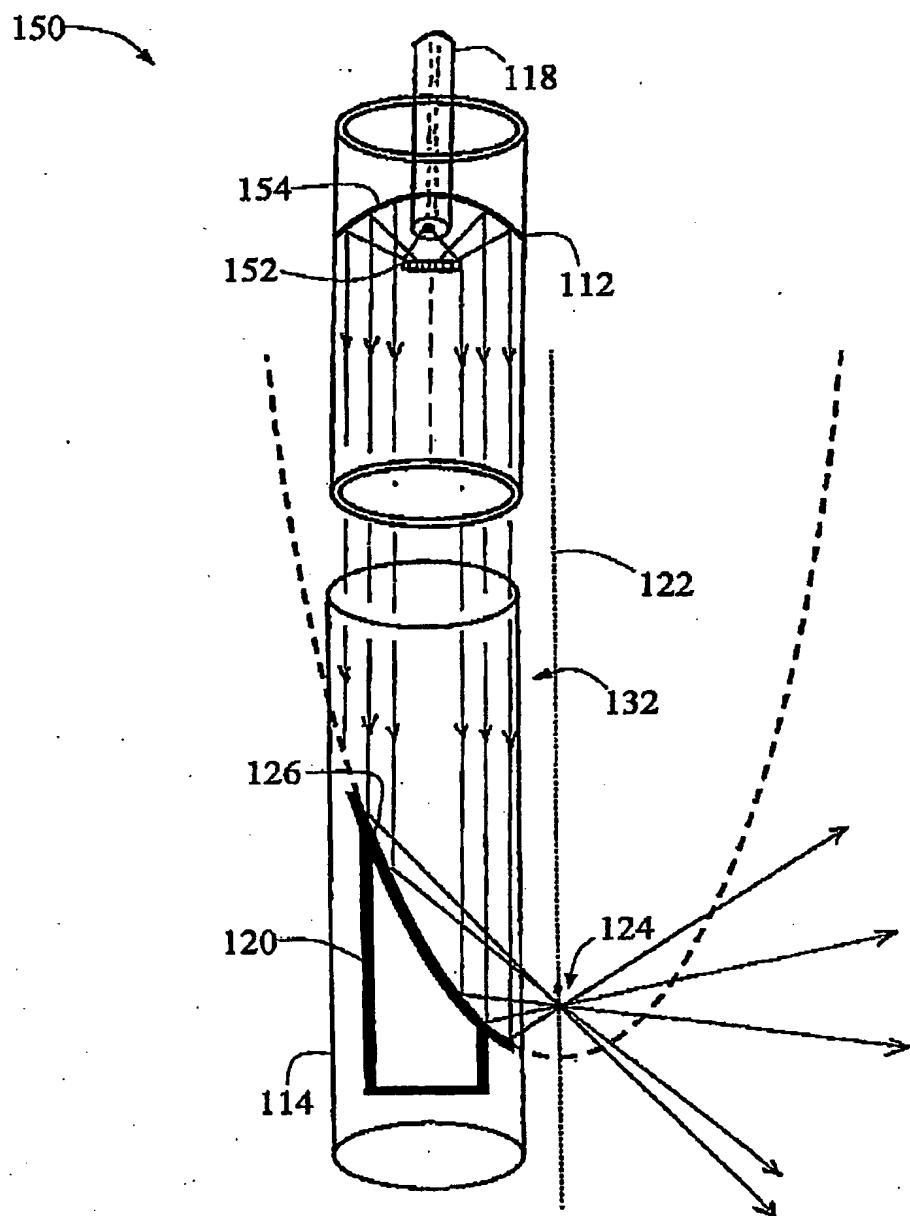


Figure 6

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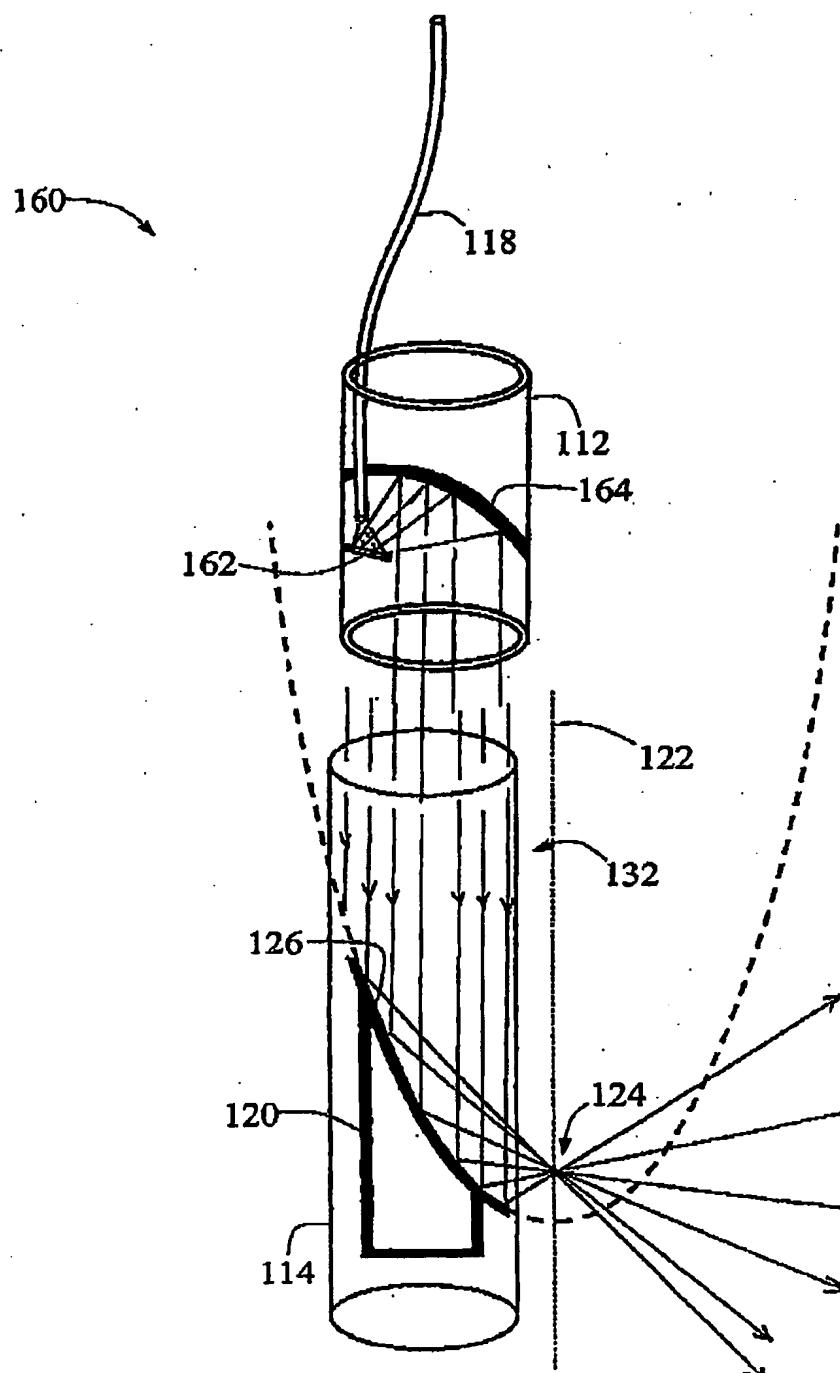


Figure 7

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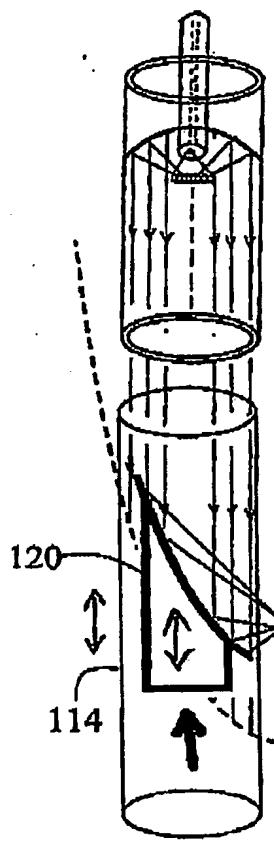


Figure 8A

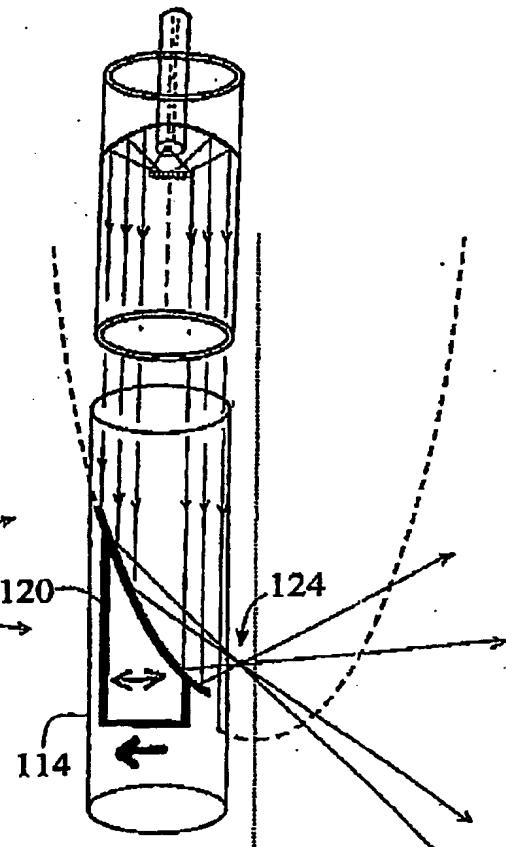


Figure 8B

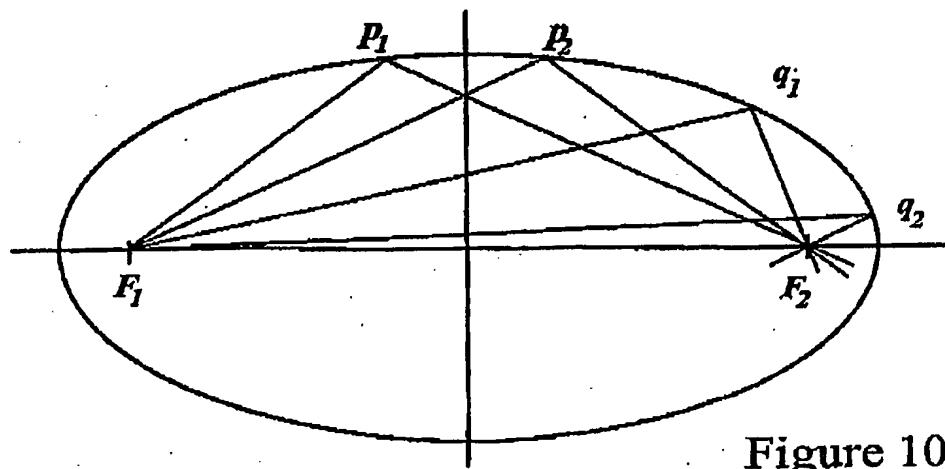


Figure 10

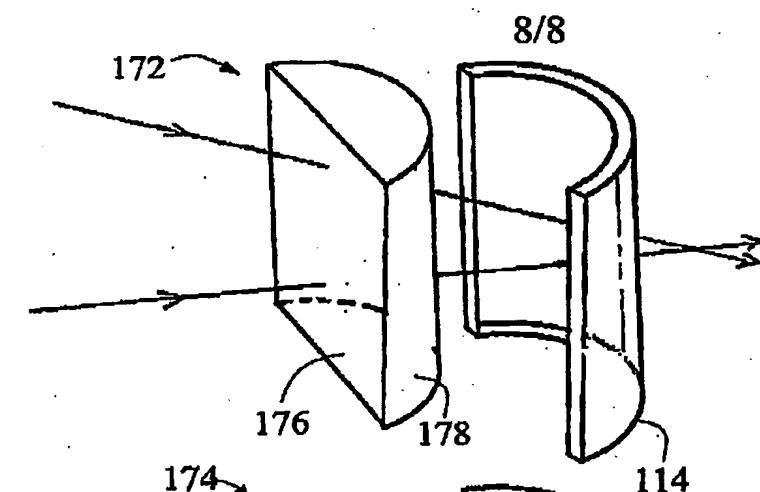


Figure 9A

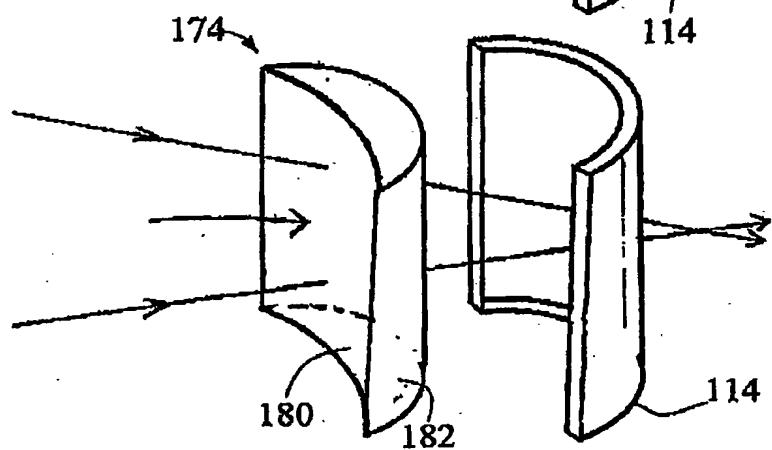


Figure 9B

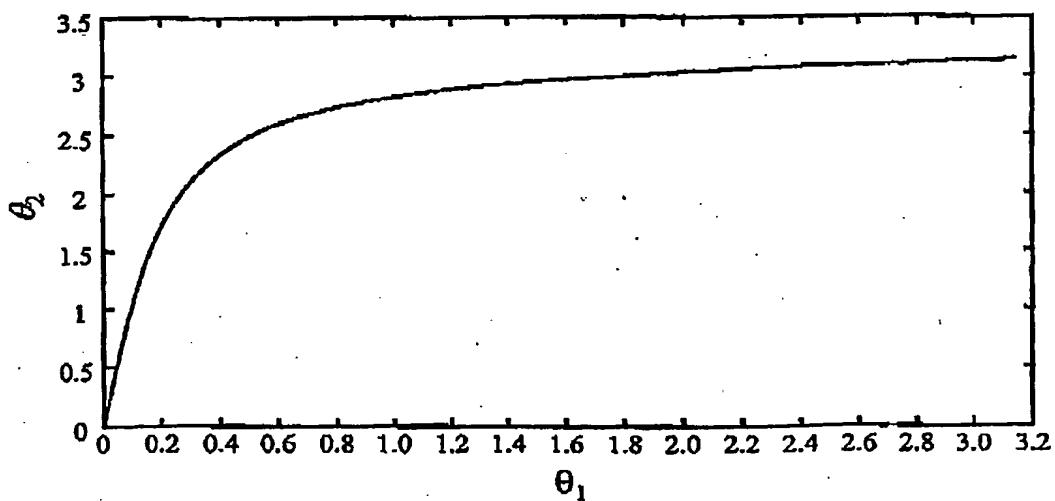


Figure 11

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING
SUBMISSION OR TRANSMITTAL
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

GRIFFITH HACK
Level 3
509 St Kilda Road
Melbourne, Victoria 3004
AUSTRALIE

Date of mailing (day/month/year) 22 April 2005 (22.04.2005)	
Applicant's or agent's file reference AJM:FP21228	IMPORTANT NOTIFICATION
International application No. PCT/AU05/000257	International filing date (day/month/year) 28 February 2005 (28.02.2005)
International publication date (day/month/year)	Priority date (day/month/year) 27 February 2004 (27.02.2004)
Applicant OPTISCAN PTY LTD et al	

1. By means of this Form, which replaces any previously issued notification concerning submission or transmittal of priority documents, the applicant is hereby notified of the date of receipt by the International Bureau of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to a date of receipt, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
2. *(If applicable)* The letters "NR" appearing in the right-hand column denote a priority document which, on the date of mailing of this Form, had not yet been received by the International Bureau under Rule 17.1(a) or (b). Where, under Rule 17.1(a), the priority document must be submitted by the applicant to the receiving Office or the International Bureau, but the applicant fails to submit the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
3. *(If applicable)* An asterisk (*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b) (the priority document was received after the time limit prescribed in Rule 17.1(a) or the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b)). Even though the priority document was not furnished in compliance with Rule 17.1(a) or (b), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

<u>Priority date</u>	<u>Priority application No.</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
27 February 2004 (27.02.2004)	2004900986	AU	15 March 2005 (15.03.2005)

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